# TRIHALOMETHANES IN ONTARIO DRINKING WATERS

## A SURVEY OF SELECTED WATER TREATMENT PLANTS

1977 - 1982

Ontario
Ministry of the Environment

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Drinking Water Section

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Ontario Ministry of the Environment

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## NOTE

Numbers presented in this report for trihalomethanes were obtained by an analysis method known as direct aqueous injection (DAI). The maximum acceptable concentration (MAC) of total trihalomethanes in drinking water is 350 ug/L (350 ppb) as analyzed by a method known as the purge-and trap. While there is not a direct relationship between the two methods, the DAI method has been shown to overestimate the actual value and can be used as a flagging mechanism to be used prior to proceeding to the specified method if needed. In addition the DAI method is extremely rapid in comparison to the purge-and-trap method, thus making it the only feasible analytical approach to cost-effectively carry out a survey of this magnitude.

A detailed discussion of the relationships between the two methods is given on pages 8, 9 and 10 of the report.

As a result of this survey those locations where total trihalomethanes exceed 300 ug/L at any time, by the DAI method, are currently being monitored using the MAC specified method of purge and trap.

## SUMMARY AND CONCLUSIONS

Trihalomethanes (THM) are formed in drinking water as a direct result of chlorination, a process primarily used for disinfection. The chlorine reacts with organic precursors found in the raw water. The Ontario Drinking Water Objectives (1983) set a maximum acceptable concentration (MAC) for total trihalomethanes (TTHM) of 350 µg/L[1].

The survey sampled 138 municipal water systems in Ontario from 1977-1982, and found that only 24 exceeded a selected threshold of 300 µg/L TTHM (DAI) (Direct Aqueous Injection). The MAC was not exceeded at most of these locations. It was apparently exceeded at seven locations but at only four of these were the high values found in the distribution system samples. One of these four locations had results that exceeded the MAC more than once. This location (Lindsay) was the only one in this survey where THM's were at problem levels. Action was taken during the survey, and by changing the point of chlorination at the treatment plant, the THM levels were substantially reduced below the MAC.

Trihalomethane levels were effectively reduced at several locations where conventional water treatment plants were installed during the survey period, probably due to lower chlorine dosages and organic precursor removal before the THM formation was complete.

It can be concluded from this survey, that in the Ontario municipal drinking waters sampled, trihalomethanes were generally very low, only approached problem levels in a few locations and, based on existing data, were not above the MAC at any consumer's tap at the end of the survey.

## TABLE OF CONTENTS


| | Page No. |
|---|---|
| SUMMARY AND CONCLUSIONS | 1 |
| TABLE OF CONTENTS | ii |
| ACKNOWLEDGEMENTS | iii |
| INTRODUCTION | 1 |
| METHODOLOGY | 7 |
| A) Sampling | 7 |
| B) Analytical | 8 |
| Table I - Comparison of Results of DAI and Sparged-DAI Techniques | 9 |
| RESULTS AND DISCUSSION | 11 |
| Table II - Peak Levels of TTHM (DAI) in Treated-Unquenched Samples | 13 |
| Table III - Annual Average Summaries of TTHM (DAI) Results from Treated-Unquenched Samples. | 20 |
| Table IV - Classification of Locations That Exceeded Threshold Level of 300 µg/L TTHM (DAI) | 23 |
| RECOMMENDATIONS FOR MONITORING | 25 |
| Figure 1 - Sampling Required and Action Needed When Monitoring THM's | 26 |
| REFERENCES | 28 |
| APPENDIX I - DETAILED ANALYTICAL METHODS | 30 |
| APPENDIX II - SURVEY SAMPLE RESULTS FOR TTHM (DAI) | 35 |
| APPENDIX III - ASSESSMENT OF LOCATIONS WHERE TTHM (DAI) RESULTS EXCEEDED 300 µg/L | 258 |

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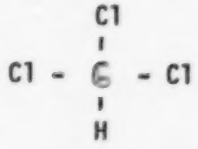
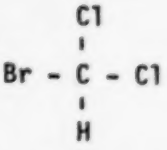
## INTRODUCTION

It has been demonstrated that the formation of trihalomethanes in drinking waters is a direct result of chlorination, a long established water treatment practice for disinfection. There is public concern for the safety of municipal water supplies because some of these chlorinated by-products may pose a risk to human health at levels above the maximum acceptable concentration.

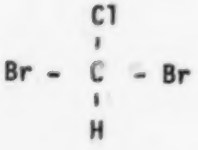
Trihalomethanes are members of a group of organic compounds that contain one carbon atom, one hydrogen atom and three halogen atoms. The halogen atoms that are important in the formation of THM's in water are chlorine, bromine and iodine. Trihalomethanes found in chlorinated drinking water are members of the family of organohalogen compounds which are named as derivatives of methane ($CH_4$), where three of the four hydrogen atoms have been replaced by three atoms of chlorine, bromine or iodine. They are formed by the action of these halogens on certain "precursors" (generally humic and fulvic substances) present in the raw water. Of the ten possible trihalomethanes, only four normally occur in significant concentration in chlorinated drinking water. The structural formulae of the four commonly associated with chlorination are as follows:



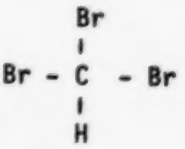
Chloroform



Dichlorobromomethane

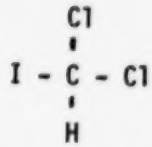


Dibromochloromethane

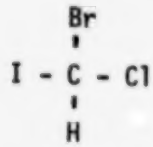


Bromoform

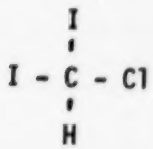
The arithmetic sum of the concentrations of the above four compounds has been defined as the "Total Trihalomethane" concentration. Where iodine is used as a disinfectant, or where iodine is naturally present in the water, several iodine-containing trihalomethanes may occur. Their structural formulae are as follows:



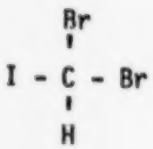
Dichloroiodomethane



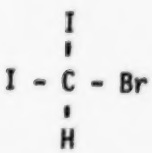
Bromochloroiodomethane



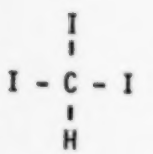
Chlorodiiodomethane



Dibromoiodomethane



Bromodiiodomethane



Triiodomethane
(Iodoform)

Following the firm establishment of a link between the formation of THM's and chlorination practice[3], several studies have been undertaken by various health authorities, governmental agencies

and other interested groups to survey the extent of problems in various water supplies and to evaluate whatever course of action could be taken to minimize the exposure to these by-products.

In Canada, the Guidelines for Drinking Water Quality (1978) established a maximum acceptable concentration of trihalomethanes in drinking water at 350 µg/L based on the purge and trap method[2]. The Ministry of the Environment (MOE), Ontario Drinking Water Objectives, adopted in April, 1983, also set the maximum acceptable concentration at 350 µg/L for TTHM. "In studies with rodents, it has been demonstrated that ingestion of large doses of chloroform results in the development of malignant tumours. Risk assessment of such data suggests that low doses of chloroform may produce some incidence of cancer: using the linear one-hit model, the maximum risk of incurring cancer for a 70 Kg adult who daily ingests 2 litres of water containing 0.35 mg of chloroform per litre would be 1 in 2.5 million per year. Drinking water with a total trihalomethane concentration of 0.35 mg/L is, therefore, considered to pose a negligible health hazard to man".[2]

The United States Environmental Protection Agency (US EPA) promulgated a regulation in November, 1979 that would set the maximum contaminant level for total trihalomethanes (TTHM) at 100 µg/L based on the purge and trap method of analysis.[4] This regulation was finalized in March, 1983. A different approach was used in the USA to assess the risk from trihalomethanes in drinking water. "Although it is generally agreed that it is not possible to project with accuracy

from risk estimates to absolute number of cancers in a human population exposed to a given agent, the approximate impact of the standard has been estimated using statistical extrapolation models derived from animal data. Statistical assessments of risk have been attempted using several mathematical models, and they indicate that the excess risk for lifetime exposure at the regulation level (100 µg/L) would be on the order of $10^{-4}$ to $10^{-5}$; that is, an excess lifetime (70 year) cancer risk in the range of one in ten thousand and one in one hundred thousand".[5]

For a more in-depth comparison of the U.S. and Canadian limits, see a paper by Calabrase.[6]

In 1974, a survey was initiated to monitor Ontario drinking water supplies for organics, including THM's. Data up to and including 1976 were presented in an MOE report published in 1977.[7] A monitoring program specifically for THM's has continued through 1984. The present report includes the data from 1977 to 1982. In 1977, 50 municipal water supplies, selected on the basis of location and population served, were monitored. In 1978, 1979, 1980, 1981 and 1982, the program was altered so that 74, 59, 111, 87 and 67 municipal water supplies, respectively, were sampled.

The following municipalities participated in the monitoring program presented in this report:

| | | |
|---|---|---|
| 1. Ajax | 10. Beeton | 19. Brantford |
| 2. Alexandria | 11. Belle River | 20. Brockville |
| 3. Amherstburg | 12. Belleville | 21. Burlington |
| 4. Arnprior | 13. Blenheim | 22. Cambridge |
| 5. Atikokan | 14. Bobcaygeon | 23. Casselman |
| 6. Bancroft | 15. Bond Head | 24. Cayuga |
| 7. Barry's Bay | 16. Bowmanville | 25. Chalk River |
| 8. Beardmore | 17. Bracebridge-Booster | 26. Chapleau |
| 9. Beaverton | 18. Bracebridge-Springs | 27. Chatham |

28. Cobalt
29. Cobden
30. Cochrane
31. Collingwood
32. Cornwall
33. Deseronto
34. Dresden
35. Dryden
36. Ear Falls
37. Eganville
38. Emo
39. Espanola
40. Fauquier
41. Fenelon Falls
42. Fort Erie
43. Fort Frances
44. Frankford-Well #1
45. Frankford-Well #2
46. Geraldton
47. Goderich
48. Grand Bend
49. Gravenhurst
50. Haileybury
51. Halton Hills
52. Hamilton
53. Harrow
54. Hastings
55. Hawkesbury
56. Hearst
57. Huntsville
58. Iroquois Falls
59. Kapuskasing
60. Kenora
61. Kingston
62. Kirkland Lake
63. L'Orignal
64. Lakefield
65. Latchford
66. Leamington
67. Lindsay
68. Longlac
69. Madoc
70. Madsen
71. Markdale
72. Marmora
73. Massey
74. Matheson
75. Mattice
76. Meaford
77. Mitchell's Bay
78. Moosonee-North
79. Moosonee-South
80. Nakina
81. Napanee
82. Newcastle
83. New Liskeard
84. Niagara Falls
85. Niagara-On-The-Lake
86. North Bay
87. Oakville
88. Odessa
89. Orillia
90. Oshawa
91. Ottawa-Brittania
92. Ottawa-Lemieux
93. Owen Sound
94. Paris
95. Parry Sound
96. Pembroke
97. Perth
98. Peterborough
99. Pickering
100. Pickle Lake
101. Picton
102. Port Colborne
103. Port Elgin
104. Powassan
105. Prescott
106. Rainy River
107. Red Lake
108. Red Rock
109. Renfrew
110. Rockland
111. Sarnia
112. Sault Ste. Marie
113. Schreiber
114. Simcoe

115. Smiths Falls
116. Southampton
117. St. Catharines
118. St. Thomas
119. Stouffville
120. Sudbury-Ramsey Lake
121. Sudbury-Wanapitei
122. Thornbury
123. Thunder Bay-Bare Point
124. Thunder Bay-Loch Lomond
125. Tilbury
126. Timmins
127. Toronto-Lakeview
128. Toronto-R.C. Harris
129. Toronto-Westerly
130. Trenton-Wells
131. Trenton-W.T.P.
132. Vankleek Hill
133. Vermillion Bay
134. Verner
135. Victoria Harbour
136. Wallaceburg
137. Welland
138. Windsor

## METHODOLOGY

A) Sampling:

The samples for the survey were requested from the water plant operators via the MOE Regional offices and were to be submitted to the MOE Toronto Laboratory on a monthly basis. After 1979, samples were collected on the first Monday of each month to reduce the time between sample collection and analysis.

The samples were collected in 180 mL glass bottles (microbiological sample bottles) with aluminum foil-lined screw caps. The sample bottles were filled to overflowing (splashing or excessive aeration was avoided) and then closed tightly. This procedure, intended to minimize headspace, would reduce volatilization of the compounds from the aqueous phase before opening of the sample bottle for analysis.

The samples were shipped to the laboratory where they were refrigerated (about $5^{o}C$) until analysis could be performed. Only prior to analysis were the bottles allowed to reach room temperature and were then opened for withdrawal of the sample. Aliquots were transferred by disposable glass pipettes (at atmospheric pressure) to hypo-vials for automatic sample injection into the gas chromatograph (G C ).

Four types of samples were analyzed for volatile organohalides:

a) "raw-unquenched"*- raw water which was not chlorinated;

b) "treated-unquenched" - chlorinated or treated water which contained residual chlorine;

c) "treated-quenched" - chlorinated quenched water containing no residual chlorine after the addition of sodium thiosulphate as the reducing agent;

d) "distribution-system-unquenched" - distribution water at the consumer's tap.



*unquenched samples have no sodium thiosulphate added.

B) Analytical:

Current analytical technology applied to drinking water has thus far detected chloroform (trichloromethane), dichlorobromomethane, chlorodibromomethane, bromoform (tribromomethane) and dichloroiodomethane. The latter two compounds have been detected in drinking water along with the chlorinated, brominated and iodinated trihalomethanes, but are not included in this report because of analytical and quantification difficulties.[3]

The Ontario MAC for TTHM's of 350 µg/L is based on the purge and trap method of analysis. This is a lengthy analysis and is not practical where a large number of samples must be rapidly processed (high volume testing). A rapid method of analysis was developed whereby a sample was first analyzed by the "Direct Aqueous Injection" (DAI) method.[8] If the TTHM (DAI) level was over a selected threshold (300 µg/L), further samples could then be analyzed by the sparged-DAI method (DAI result minus DAI result after sparging), which is equivalent to the result obtained by the purge and trap method.[9, 10]

To establish the relationship between the DAI method and the sparged-DAI method, seventeen municipalities with TTHM (DAI) levels exceeding 300 µg/L were resamplied in May and June, 1983 and reanalyzed by the DAI and sparged-DAI techniques; the results are presented in Table I.

TABLE 1

COMPARISON OF RESULTS OF DAI AND SPARGED-DAI* TECHNIQUES

| | Location | TTHM ( µg/L ) DAI | Sparged-DAI | Factor |
|---|---|---|---|---|
| 1. | Atikokan | 349 | 90 | 3.88 |
| 2. | Bancroft | 147 | 100 | 1.47 |
| 3. | Bobcaygeon | 164 | 97 | 1.69 |
| 4. | Brantford | 255 | 161 | 1.58 |
| 5. | Casselman | 380 | 272 | 1.40 |
| 6. | Cayuga | 331 | 164 | 2.02 |
| 7. | Chapleau | 218 | 110 | 1.98 |
| 8. | Ear Falls | 172 | 133 | 1.29 |
| 9. | Emo | 345 | 214 | 1.62 |
| 10. | Fort Frances | 127 | 78 | 1.63 |
| 11. | Frankford | 181 | 66 | 2.74 |
| 12. | Hearst | 74 | 50 | 1.48 |
| 13. | Lindsay | 270 | 183 | 1.48 |
| 14. | Madsen | 116 | 92 | 1.26 |
| 15. | Odessa | 159 | 93 | 1.71 |
| 16. | Rockland | 38 | 26 | 1.46 |
| 17. | Smiths Falls | 355 | 248 | 1.43 |

*The sparged-DAI method of analysis is equivalent to the purge and trap procedure.

The results by the DAI method were always higher than by the sparged-DAI technique by a factor of between 1.26 and 3.88. It is, therefore, impossible to apply a common factor to all locations to determine the sparged-DAI equivalent from a DAI result. Each water was unique and there were also variations expected in the factor at each location due to seasonal changes in water quality.

In 1984, the laboratory acquired additional analytical capability that allowed the purge and trap method to be used on the few samples that exceeded the threshold level. The sparged-DAI, while still equivalent to the purge and trap method, was phased out at that time. The sections that deal with recommendations for monitoring (page 25) and Appendix III (pages 258-290) which deals with locations where samples exceeded the threshold, reflect this change.

## RESULTS AND DISCUSSION

The results from 1977 to 1982 are presented in Appendix II. It should be understood that these were obtained by the DAI technique and levels would have been lower if the purge and trap technique had been used. There was considerable variation in the TTHM (DAI) levels both with the sample types and with time. With very few exceptions, the raw-unquenched samples had the lowest levels of TTHM (DAI), usually below the detection limit. In the treated water, the quenched sample (sodium thiosulphate added) usually had lower TTHM (DAI) levels than the unquenched sample, this was expected since the sodium thiosulphate terminated the action of chlorine and any further THM formation. The locations where there was little or no difference between the levels in the quenched and unquenched samples may indicate that there was a very low chlorine residual or the level of precursors was very low. The unquenched samples from the distribution systems were not available from every location and were not sampled on a regular basis prior to 1978. Their TTHM (DAI) levels were generally lower than in the treated-unquenched samples taken at the water treatment plant (WTP) possibly due to adsorption, oxidation or biological reactions occurring within the mains. Generally, TTHM (DAI) levels were significantly higher during the late summer months than any other time of the year.

Results from the treated-unquenched samples (values listed in Appendix II) indicated that chloroform was the most common trihalomethane found in the survey. On average, 79% of the TTHM (DAI) detected was chloroform; 16% was dichlorobromomethane; 5% was dibromochloromethane. The percentage of chloroform in the TTHM (DAI) results appeared to be related to the source and location in the Province. The lowest percentage

of chloroform (<50-70%) were generally from groundwaters and surface water from the lower Great Lakes unaffected by river water. Slightly higher percentages (60-90%) were found in other surface waters in Southern Ontario west of Lake Simcoe, while surface supplies in northern (including Lake Superior) and eastern Ontario almost invariably had 90% or more of TTHM (DAI) results as chloroform.

Peak levels of TTHM (DAI) in treated-unquenched samples are found in Table II. The locations (WTP's) are divided into four groups with peak TTHM (DAI) levels of 0-100, 101-200, 201-300 and >300 µg/L. The latter was selected as a threshold level to indicate possible problems. When the threshold was exceeded, the intention was to resample the flagged location and analyze by the sparged-DAI to confirm the result and for comparison with the MAC. Unfortunately, this was not done on a routine basis. Water plants with TTHM (DAI) levels of >300 µg/L are discussed in detail in Appendix III.

In data from 1974-1976, there was one municipality, of the 48 tested, with a level of TTHM (DAI) greater than 300 µg/L in the treated-unquenched water.[7]

Of the municipalities surveyed in 1977, there was one with a TTHM (DAI) level greater than 300 µg/L (2% of those surveyed); in 1978, there were 2 municipalities (2.7% of municipalities surveyed); in 1979, there were 4 municipalities (6.7% of those surveyed); in 1980, there were 13 municipalities (11.7% of municipalities surveyed); in 1981 there were 11 municipalities (12.6% of those surveyed); and in 1982 there were 11 municipalities with levels exceeding 300 µg/L (17.2% of municipalities surveyed).

TABLE II

ANNUAL PEAK LEVELS OF TTHM (DAI) IN TREATED-UNQUENCHED SAMPLES

| Range (µg/L) | Year 1977 | | |
|---|---|---|---|
| 0-100 | Blenheim<br>Burlington<br>Chatham<br>Cochrane<br>Dryden<br>Fort Erie<br>Grand Bend<br>Hawkesbury<br>Iroquois Falls<br>Kapuskasing | Kingston<br>Leamington<br>Meaford<br>Newcastle<br>Niagara Falls<br>Niagara-on-the-Lake<br>North Bay<br>Oakville<br>Pembroke<br>Port Colborne | Sarnia<br>Sault Ste Marie<br>St. Catharines<br>St. Thomas<br>Sudbury-Ramsey Lake WTP<br>Toronto - R.C. Harris<br>Toronto - Westerly<br>Windsor |
| 101-200 | Amherstburg<br>Dresden<br>Espanola<br>Fort Frances<br>Goderich | Geraldton<br>Harrow<br>Kenora<br>Napanee<br>Smiths Falls | Southampton<br>Sudbury-Wanapitei<br>Thunder Bay-L. Lomond<br>Thunder Bay-Bare Point WTP<br>Trenton |
| 201-300 | Belleville<br>Brantford<br>Cayuga | Chapleau<br>Fauquier<br>Timmins | |
| >300 | Emo | | |

Table II - cont'd.

ANNUAL PEAK LEVELS OF TTHM (DAI) IN TREATED-UNQUENCHED SAMPLES

| Range (µg/L) | Year 1978 | | |
|---|---|---|---|
| 0-100 | Ajax<br>Amherstburg<br>Beeton<br>Blenheim<br>Bond Head<br>Bowmanville<br>Brockville<br>Burlington<br>Cambridge<br>Chalk River<br>Chatham<br>Cochrane<br>Cornwall<br>Fort Erie<br>Goderich<br>Grand Bend<br>Hawkesbury<br>Kapuskasing<br>Kingston | Kirkland Lake<br>Leamington<br>Massey<br>Matheson<br>Meaford<br>Newcastle<br>Niagara Falls<br>Niagara-on-the-Lake<br>North Bay<br>Oakville<br>Orillia<br>Oshawa<br>Pembroke<br>Port Colborne<br>Prescott<br>Red Rock<br>Renfrew | St. Catharines<br>St. Thomas<br>Sarnia<br>Sault Ste Marie<br>Southampton<br>Stouffville<br>Sudbury-Ramsey L. WTP<br>Sudbury-Wanapitei<br>Tilbury<br>Toronto-R.C. Harris<br>Windsor |
| 101-200 | Atikokan<br>Dresden<br>Emo<br>Fauquier<br>Fenelon Falls<br>Geraldton<br>Haileybury | Hastings<br>Harrow<br>Longlac<br>Iroquois Falls<br>Moosonee-North<br>Moosonee-South<br>Napanee | Perth<br>Smiths Falls<br>Timmins<br>Toronto-Westerly<br>Trenton<br>Thunder Bay-L. Lomond<br>Thunder Bay-Bare Pt. WTP |
| 201-300 | Brantford<br>Cayuga | Fort Frances<br>Peterborough | |
| >300 | Chapleau<br>Lindsay | | |

Table II - cont'd.

ANNUAL PEAK LEVELS OF TTHM (DAI) IN TREATED-UNQUENCHED SAMPLES

| Range (µg/L) | Year 1979 | | |
|---|---|---|---|
| 0-100 | Ajax<br>Alexandria<br>Amherstburg<br>Barry's Bay<br>Burlington<br>Cambridge<br>Collingwood<br>Halton Hills<br>Haileybury<br>Hawkesbury | Kapuskasing<br>Markdale<br>Mitchell's Bay<br>Moosonee-North<br>North Bay<br>New Liskeard<br>Niagara Falls<br>Niagara-on-the-Lake<br>Paris | Pembroke<br>Pickering<br>Red Rock<br>Southampton<br>St. Thomas<br>Sudbury-Ramsey Lake WTP<br>Tilbury<br>Wallaceburg |
| 101-200 | Beaverton<br>Belleville<br>Bracebridge-Muskoka Booster<br>Bracebridge-Peak Springs<br>Chapleau<br>Dresden<br>Espanola<br>Fauquier | Fenelon Falls<br>Fort Frances<br>Geraldton<br>Harrow<br>Iroquois Falls<br>Kirkland Lake<br>Lakefield | Latchford<br>Moosonee-South<br>Napanee<br>Smiths Falls<br>Sudbury-Wanapitei<br>Thunder Bay-L. Lomond<br>Thunder Bay-Bare Point<br>Trenton |
| 201-300 | Emo<br>Hastings | Peterborough<br>Rainy River<br>Timmins | |
| >300 | Brantford<br>Cayuga<br>Hearst<br>Lindsay | | |

Table II - cont'd.

ANNUAL PEAK LEVELS OF TTHM (DAI) IN TREATED-UNQUENCHED SAMPLES

| Range (µg/L) | Year 1980 | | |
|---|---|---|---|
| 0-100 | Ajax<br>Amherstburg<br>Barry's Bay<br>Belle River<br>Bowmanville<br>Chalk River<br>Chatham<br>Cobalt<br>Cobden<br>Cochrane<br>Collingwood<br>Dryden<br>Eganville<br>Fenelon Falls<br>Frankford Well #2<br>Geraldton<br>Goderich<br>Grand Bend<br>Hamilton<br>Hawkesbury | Huntsville<br>Kapuskasing<br>Kingston<br>Kirkland Lake<br>Leamington<br>Longlac<br>L'Orignal<br>Nakina<br>New Liskeard<br>Niagara Falls<br>Niagara-on-the-Lake<br>Oakville<br>Oshawa<br>Owen Sound<br>Paris<br>Parry Sound<br>Pembroke<br>Pickering<br>Pickle Lake | Port Elgin<br>Red Rock<br>Renfrew<br>Sarnia<br>Simcoe<br>Southampton<br>St. Thomas<br>Sudbury-Ramsey Lake WTP<br>Sudbury-Wanapitei<br>Thornbury<br>Toronto-Lakeview<br>Trenton-W.T.P.<br>Trenton-Wells<br>Vankleek Hill<br>Wallaceburg<br>Welland<br>Windsor |
| 101-200 | Alexandria<br>Arnprior<br>Beardmore<br>Beaverton<br>Belleville<br>Chapleau<br>Deseronto<br>Fauquier<br>Gravenhurst<br>Haileybury | Harrow<br>Iroquois Falls<br>Kenora<br>Lakefield<br>Latchford<br>Marmora<br>Mitchell's Bay<br>Moosonee-South<br>Napanee<br>Orillia<br>Ottawa-Britannia | Ottawa-Lemieux<br>Picton<br>Smiths Falls<br>Thunder Bay-L. Lomond<br>Thunder Bay-Bare Point WTP<br>Tilbury<br>Timmins<br>Vermillion Bay<br>Verner |
| 201-300 | Cayuga<br>Dresden<br>Hastings<br>Moosonee-North<br>Odessa | Perth<br>Peterborough<br>Powassan<br>Rainy River | Red Lake<br>Schreiber<br>Sudbury-Wanapitei<br>Victoria Harbour |
| >300 | Atikokan<br>Bancroft<br>Bobcaygeon<br>Brantford<br>Casselman | Ear Falls<br>Emo<br>Fort Frances<br>* Frankford Well #1<br>Hearst | Lindsay<br>Madsen<br>Rockland |

*anomalous situation see page 272

Table II - cont'd.

ANNUAL PEAK LEVELS OF TTHM (DAI) IN TREATED-UNQUENCHED SAMPLES

| Range (µg/L) | Year 1981 | | |
|---|---|---|---|
| 0-100 | Ajax | Kirkland Lake | Pickle Lake |
| | Beaverton | Leamington | Picton |
| | Bowmanville | L'Orignal | Rockland |
| | Cobden | Marmora | Sarnia |
| | Collingwood | Nakina | Sudbury-Ramsey L. WTP |
| | Frankford Well #2 | Niagara Falls | Sudbury-Wanapitei |
| | Geraldton | Oakville | Toronto-Lakeview |
| | Grand Bend | Orillia | Vankleek Hill |
| | Haileybury | Oshawa | Welland |
| | Hamilton | Owen Sound | Windsor |
| | Hawkesbury | Paris | |
| | | Parry Sound | |
| 101-200 | Alexandria | Harrow | Powassan |
| | Amherstburg | Iroquois Falls | Renfrew |
| | Arnprior | Kenora | Schreiber |
| | Belle River | Latchford | St. Thomas |
| | Bracebridge-Muskoka Booster | Mitchell's Bay | Thunder Bay - Bare Point WTP |
| | Chapleau | Mattice | Thornbury |
| | Chatham | Niagara-on-the-Lake | Vermillion Bay |
| | Dresden | Ottawa-Brittania | Verner |
| | Eganville | Ottawa-Lemieux | Warkworth |
| | Gravenhurst | Pembroke | |
| 201-300 | Barry's Bay | Goderich | Rainy River |
| | Belleville | Hearst | Red Lake |
| | Bobcaygeon | Napanee | Thunder Bay-Loch Lomond |
| | Brantford | Peterborough | Victoria Harbour |
| | Deseronto | Port Elgin | |
| >300 | Atikokan | Fort Frances | Smiths Falls |
| | Bancroft | *Frankford Well #1 | |
| | Casselman | Lindsay | |
| | Ear Falls | Madsen | |
| | Emo | Odessa | |

*anomalous situation see page 272

Table II - cont'd.

ANNUAL PEAK LEVELS OF TTHM (DAI) IN TREATED-UNQUENCED SAMPLES

| Range (µg/L) | Year 1982 | |
|---|---|---|
| 0-100 | Ajax<br>Beaverton<br>Belle River<br>Blenheim<br>Bowmanville<br>Chatham<br>Frankford-Well #2<br>Goderich<br>Grand Bend<br>Huntsville<br>Marmora<br>Mattice<br>Oakville<br>Orillia | Oshawa<br>Ottawa-Lemieux<br>Owen Sound<br>Paris<br>Pickering<br>Renfew<br>Rockland<br>Sarnia<br>St. Thomas-Elgin Area<br>Thunder Bay-Bare Point<br>Welland |
| 101-200 | Alexandria<br>Amherstburg<br>Barry's Bay<br>Cayuga<br>Cobden<br>Dresden<br>Eganville<br>Gravenhurst | Harrow<br>Iroquois Falls<br>Kenora<br>Leamington-Union<br>Mitchell's Bay<br>Ottawa-Brittania<br>Pembroke<br>Victoria Harbour |
| 201-300 | Bancroft<br>Belleville<br>Bobcaygeon<br>Casselman<br>Chapleau<br>Emo<br>Hearst | Niagara Falls<br>Niagara-on-the-Lake<br>Peterborough<br>Rainy River<br>Thunder Bay-Loch Lomond |
| >300 | Atikokan<br>Deseronto<br>Ear Falls<br>*Frankford-Well #1<br>Hamilton | Lindsay<br>Madsen<br>Napanee<br>Odessa<br>Smiths Falls<br>Verner |

*anomalous situation see page 272

The averages for TTHM (DAI) results in the treated-unquenched samples for each year from 1977-82 are in Table III. As can be seen, the results were usually very low, indicating that only a few locations exceeded the threshold level of 300 µg/L on a continuous basis.

Of the 138 municipal water supplies monitored between 1977 and 1982, 21 had TTHM (DAI) levels over the threshold of 300 µg/L in the treated-unquenched samples. In addition, three locations had TTHM (DAI) levels that exceeded the threshold in only the distribution system samples. The 24 locations were arranged in groups according to their probability of having problem levels of trihalomethanes based on the number of times the threshold was exceeded (Table IV). Each of these locations was dealt with individually (Appendix III, Pages 257 to 289) to assess the available analysis and determine if the MAC was exceeded. On the basis of this information, a plan of action was developed which outlined the sampling and analysis required to clarify each situation.

Of the 24 locations where the threshold level was exceeded, most did not appear to exceed the MAC with the available data. A few locations need more sampling and analysis to confirm this probability. The MAC appeared to be exceeded at seven locations but at three of these (Bancroft, Madsen and Frankford Well #1), the treatment was only chlorination and the results above the limit were only found in the samples taken at the water plant, after chlorine addition, not in the samples from the distribution system. At one of these locations (Frankford Well #1), the very high levels were apparently due to the improper mixing of the chlorine prior to the sampling point. This may have been part of the problem at the other two locations.

TABLE III

ANNUAL AVERAGE SUMMARIES OF TTHM (DAI)

RESULTS FROM TREATED-UNQUENCHED SAMPLES

| Location | Region* | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|
| AJAX | C | NS | 32 | 18 | 22 | 31 | 28 |
| ALEXANDRIA | SE | NS | NS | NS | 93 | 86 | 88 |
| AMHERSTBURG | SW | 90 | 39 | 42 | 40 | 68 | 69 |
| ARNPRIOR | SE | NS | NS | NS | 88 | 111 | NS |
| ATIKOKAN | NW | NS | 114 | NS | 248 | 282 | 302 |
| BANCROFT | SE | NS | NS | NS | 155 | 262 | 146 |
| BARRY'S BAY | SE | NS | NS | 26 | 29 | 162 | 112 |
| BEARDMORE | NW | NS | NS | NS | 137 | NS | NS |
| BEAVERTON | C | NS | NS | 82 | 69 | 67 | 49 |
| BEETON | C | NS | 14 | NS | NS | NS | NS |
| BELLE RIVER | SW | NS | NS | NS | 38 | 73 | 50 |
| BELLEVILLE | SE | 163 | NS | 113 | 131 | 176 | 158 |
| BLENHEIM | SW | 34 | 28 | NS | NS | NS | 36 |
| BOBCAYGEON | C | NS | NS | NS | 231 | 166 | 275 |
| BOND HEAD | C | NS | 17 | NS | NS | NS | NS |
| BOWMANVILLE | C | NS | 28 | NS | 15 | 13 | 13 |
| BRACEBRIDGE-L. MUSKOKA | C | NS | NS | 73 | NS | 189 | NS |
| BRACEBRIDGE-L. SPRINGS | C | NS | NS | 10 | NS | 13 | NS |
| BRANTFORD | WC | 211 | 156 | 177 | 238 | 201 | NS |
| BROCKVILLE | SE | NS | 35 | NS | NS | NS | NS |
| BURLINGTON | C | 31 | 32 | 36 | NS | NS | NS |
| CAMBRIDGE | WC | NS | 0 | ND | NS | NS | NS |
| CASSELMAN | SE | NS | NS | NS | 197 | 172 | 146 |
| CAYUGA | WC | 141 | 213 | 165 | 156 | NS | 102 |
| CHALK RIVER | SE | NS | 10 | NS | 36 | NS | NS |
| CHAPLEAU | NE | 198 | 219 | 114 | 102 | 135 | 126 |
| CHATHAM | SW | 27 | 32 | NS | 43 | 76 | 68 |
| COBALT | NE | NS | NS | NS | 33 | NS | NS |
| COBDEN | SE | NS | NS | NS | 73 | 106 | 100 |
| COCHRANE | NE | 1 | 5 | NS | 13 | NS | NS |
| COLLINGWOOD | C | NS | NS | 22 | 21 | 25 | NS |
| CORNWALL | SE | NS | 26 | NS | NS | NS | NS |
| DESERONTO | SE | NS | NS | NS | 85 | 120 | 154 |
| DRESDEN | SW | 111 | 95 | 111 | 127 | 122 | 108 |
| DRYDEN | NW | 70 | NS | NS | 69 | NS | NS |
| EAR FALLS | NW | NS | NS | NS | 249 | 235 | 227 |
| EGANVILLE | SE | NS | NS | NS | 53 | 106 | 91 |
| EMO | NW | 213 | 140 | 166 | 201 | 190 | 165 |
| ESPANOLA | NE | 50 | NS | 71 | NS | NS | NS |
| FAUQUIER | NE | 169 | 84 | 99 | 138 | NS | NS |
| FENELON FALLS | C | NS | 117 | 78 | 77 | NS | NS |
| FORT ERIE | WC | 42 | 58 | NS | NS | NS | NS |
| FORT FRANCES | NW | 75 | 117 | 126 | 170 | 150 | NS |
| FRANKFORD-WELL #1 | SE | NS | NS | NS | 359 | 861 | 318 |
| FRANKFORD-WELL #2 | SE | NS | NS | NS | ND | 3 | 1 |
| GERALDTON | NW | 123 | NS | 84 | 48 | 47 | NS |
| GODERICH | SW | 58 | 42 | NS | 50 | 90 | 59 |
| GRAND BEND | SW | 29 | 15 | NS | 27 | 26 | 31 |
| GRAVENHURST | C | NS | NS | NS | 61 | 73 | 57 |
| HAILEYBURY | NE | NS | 70 | 66 | 79 | 79 | NS |

TABLE III - cont'd.

| Location | Region* | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|
| HALTON HILLS | C | NS | NS | 36 | NS | NS | NS |
| HAMILTON | WC | NS | NS | NS | 30 | 26 | 57 |
| HARROW | SW | 92 | 85 | 74 | 77 | 96 | 82 |
| HASTINGS | C | NS | 143 | 150 | 156 | NS | NS |
| HAWKESBURY | SE | 25 | 29 | 27 | 50 | 69 | NS |
| HEARST | NE | NS | NS | 447 | 183 | 161 | 133 |
| HUNTSVILLE | C | NS | NS | NS | 37 | NS | 88 |
| IROQUOIS FALLS | NE | 69 | 73 | 77 | 91 | 98 | 89 |
| KAPUSKASING | NE | 48 | 42 | 50 | 48 | NS | NS |
| KENORA | NW | 84 | NS | NS | 106 | 134 | 121 |
| KINGSTON | SE | 35 | 36 | NS | 38 | NS | NS |
| KIRKLAND LAKE | NE | NS | 72 | 55 | 40 | 46 | NS |
| L'ORIGNAL | SE | NS | NS | NS | ND | ND | NS |
| LAKEFIELD | C | NS | NS | 83 | 125 | NS | NS |
| LATCHFORD | NE | NS | NS | 121 | 126 | 108 | NS |
| LEAMINGTON-UNION | SW | 45 | 45 | NS | 56 | 66 | 59 |
| LINDSAY | C | NS | 317 | 346 | 500 | 469 | 263 |
| LONGLAC | NW | NS | 112 | NS | 33 | NS | NS |
| MADOC | SE | NS | NS | NS | NS | ND | NS |
| MADSEN | NW | NS | NS | NS | 219 | 392 | 341 |
| MARKDALE | SW | NS | NS | 9 | NS | NS | NS |
| MARMORA | SE | NS | NS | NS | 78 | 45 | 52 |
| MASSEY | NE | NS | 28 | NS | NS | NS | NS |
| MATHESON | NE | NS | 20 | NS | NS | NS | NS |
| MATTICE | NE | NS | NS | NS | NS | 22 | 8 |
| MEAFORD | SW | 18 | 13 | NS | NS | NS | NS |
| MITCHELL'S BAY | SW | NS | NS | 42 | 73 | 118 | 97 |
| MOOSONEE-NORTH | NE | NS | 92 | 40 | 137 | NS | NS |
| MOOSONEE-SOUTH | NE | NS | 39 | 127 | 112 | NS | NS |
| NAKINA | NW | NS | NS | NS | 2 | 0 | NS |
| NAPANEE | SE | 54 | 55 | 74 | 71 | 150 | 120 |
| NEWCASTLE | C | 24 | 26 | NS | NS | NS | NS |
| NEW LISKEARD | NE | NS | NS | ND | ND | NS | NS |
| NIAGARA FALLS | WC | 27 | 23 | 25 | 26 | 24 | 49 |
| NIAGARA-ON-THE-LAKE | WC | 36 | 27 | 36 | 29 | 41 | 71 |
| NORTH BAY | NE | 43 | 39 | 38 | NS | NS | NS |
| OAKVILLE | C | 27 | 29 | NS | 31 | 28 | 34 |
| ODESSA | SE | NS | NS | NS | 155 | 194 | 212 |
| ORILLIA | C | NS | 55 | NS | 65 | 77 | 55 |
| OSHAWA | C | NS | 28 | NS | 39 | 40 | 40 |
| OTTAWA-BRITTANIA | SE | NS | NS | NS | 110 | 84 | 80 |
| OTTAWA-LEMIEUX | SE | NS | NS | NS | 102 | 75 | 63 |
| OWEN SOUND | SW | NS | NS | NS | 46 | 49 | 42 |
| PARIS | WC | NS | NS | 5 | 17 | 20 | 27 |
| PARRY SOUND | NE | NS | NS | NS | 30 | 17 | NS |
| PEMBROKE | SE | 48 | 31 | 48 | 46 | 96 | 83 |
| PERTH | SE | NS | 115 | NS | 180 | NS | NS |
| PETERBOROUGH | C | NS | 160 | 159 | 173 | 192 | 199 |
| PICKERING | C | NS | NS | 16 | 23 | NS | 28 |
| PICKLE LAKE | NW | NS | NS | NS | 1 | 2 | NS |

Table III - cont'd.

| Location | Region* | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|
| PICTON | SE | NS | NS | NS | 67 | 46 | NS |
| PORT COLBORNE | WC | 24 | 20 | NS | NS | NS | NS |
| PORT ELGIN | SW | NS | NS | NS | 27 | 71 | NS |
| POWASSAN | NE | NS | NS | NS | 161 | 102 | NS |
| PRESCOTT | SE | NS | 15 | NS | NS | NS | NS |
| RAINY RIVER | NW | NS | NS | 208 | 184 | 163 | 152 |
| RED LAKE | NW | NS | NS | NS | 194 | 189 | NS |
| RED ROCK | NW | NS | 71 | 34 | 49 | NS | NS |
| RENFREW | SE | NS | 47 | NS | 59 | 84 | 51 |
| ROCKLAND | SE | NS | NS | NS | 70 | 31 | 19 |
| SARNIA | SW | 33 | 26 | NS | 40 | 52 | 48 |
| SAULT STE MARIE | NE | 1 | 1 | NS | NS | NS | NS |
| SCHREIBER | NW | NS | NS | NS | 209 | NS | NS |
| SIMCOE | WC | NS | NS | NS | 31 | NS | NS |
| SMITHS FALLS | SE | 78 | 75 | 65 | 81 | 175 | 210 |
| SOUTHAMPTON | SW | 54 | 34 | 36 | 39 | NS | NS |
| ST. CATHARINES | WC | 25 | 21 | NS | NS | NS | NS |
| ST. THOMAS-ELGIN AREA | SW | 58 | 53 | 47 | 42 | 55 | 40 |
| STOUFFVILLE | C | NS | 19 | NS | NS | NS | NS |
| SUDBURY-RAMSEY LAKE W.T.P. | NE | 51 | 30 | 24 | NS | NS | NS |
| SUDBURY-WANAPITEI W.T.P. | NE | 106 | 69 | 60 | 42 | 43 | NS |
| THORNBURY | SW | NS | NS | NS | 23 | 46 | NS |
| THUNDER BAY-BARE POINT W.T.P. | NW | 67 | 61 | 55 | 54 | 52 | 56 |
| THUNDER BAY-LOCH LOMOND | NW | 106 | 110 | 110 | 116 | 188 | 168 |
| TILBURY | SW | NS | 28 | 27 | 131 | NS | NS |
| TIMMINS | NE | 145 | 90 | 168 | 156 | NS | NS |
| TORONTO-LAKEVIEW | C | NS | NS | NS | 40 | 28 | NS |
| TORONTO-R.C. HARRIS | C | 17 | 15 | NS | NS | NS | NS |
| TORONTO-WESTERLY | C | 25 | 31 | NS | NS | NS | NS |
| TRENTON-WELLS | SE | NS | NS | NS | 9 | NS | NS |
| TRENTON W.T.P. | SE | 112 | 114 | 65 | 62 | NS | NS |
| VANKLEEK HILL | SE | NS | NS | NS | ND | 5 | NS |
| VERMILLION BAY | NW | NS | NS | NS | 88 | 108 | NS |
| VERNER | NE | NS | NS | NS | 110 | 97 | 128 |
| VICTORIA HARBOUR | C | NS | NS | NS | 137 | 128 | 100 |
| WALLACEBURG | SW | NS | NS | 65 | 44 | NS | NS |
| WELLAND | WC | NS | NS | NS | 34 | 38 | 32 |
| WINDSOR | SW | 48 | 36 | NS | 41 | 46 | NS |

All Results in µg/L

ND - not detected
NS - not sampled

* C - Central
NE - North East
NW - North West
SE - South East
SW - South West
WC - West Central

TABLE IV

CLASSIFICATION OF LOCATIONS THAT EXCEEDED
THE THRESHOLD LEVEL OF 300 µg/L TTHM (DAI)*

(unquenched sample results from WTP
treated and distribution system)

1) Exceeded threshold frequently, often by a considerable margin.

Frankford Well #1, Lindsay, Madsen

2) Exceeded threshold several times but usually below that level.

Atikokan, Bobcaygeon, Brantford, Casselman, Chapleau, Ear Falls, Emo, Hearst, Odessa, Rainy River, Smith Falls

3) Exceeded threshold only once.

Bancroft, Cayuga, Deseronto, Fort Frances, Hamilton, Napanee, Niagara-on-the-Lake, Rockland, Thunder Bay (Loch Lomond), Verner

* each location is dealt with in detail in Appendix III, pages 258 to 290

The MAC was exceeded in the distribution system samples at four locations and at three of these (Ear Falls, Hearst and Rainy River) in just one sample. At the latter two locations, conventional water treatment plants have been installed which resulted in substantially reduced THM levels. At these locations the reductions were evident even though prechlorination was being used. This was probably because lower chlorine dosages were used and THM precursors were removed by the treatment processes before the THM formation was complete. At Rainy River, changing from prechlorination to postchlorination did not appear to reduce the THM's further. At Ear Falls, more samples and analysis are required to clarify the situation.

At only one location (Lindsay) were the results from the distribution system samples regularly above the MAC. In 1982, prechlorination was discontinued in an attempt to reduce these levels. Following this change, all sample results were below the MAC.

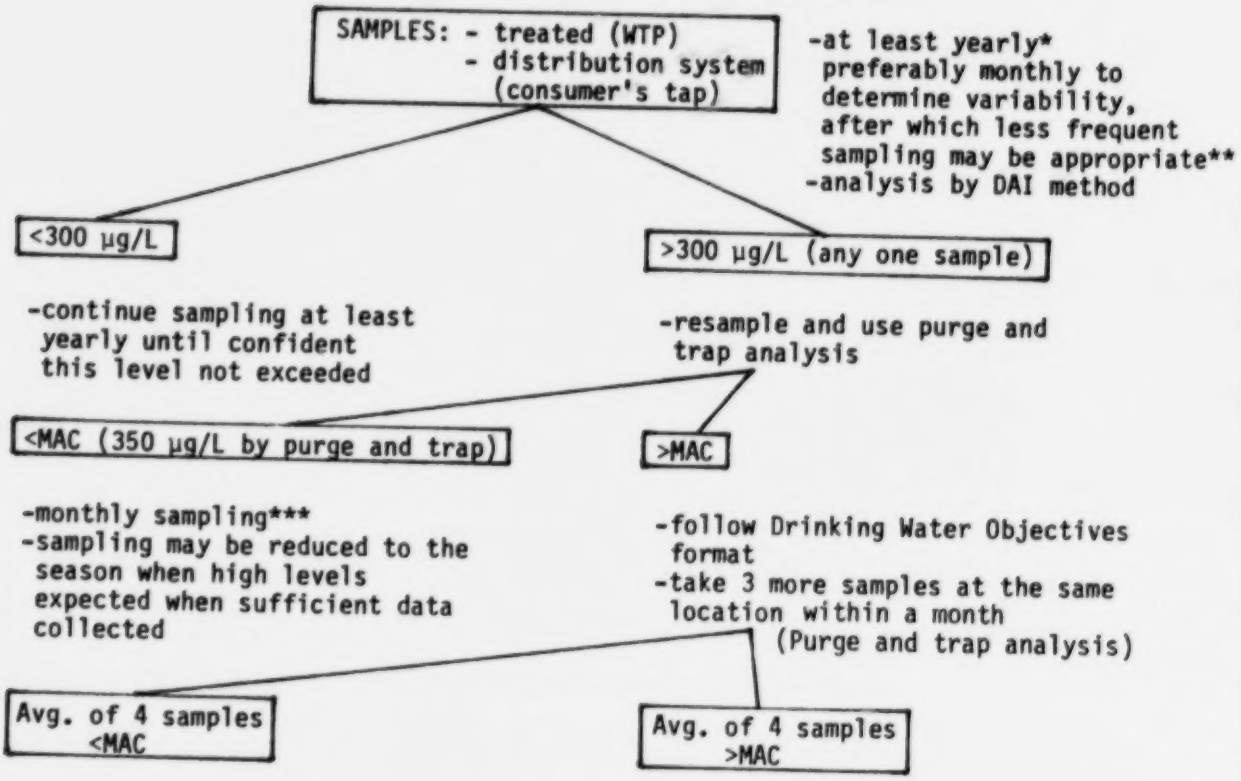
## RECOMMENDATIONS FOR MONITORING

For compliance with the Drinking Water Objectives, samples are only required from consumer's taps, but from this survey the treated-unquenched sample at the WTP served as a useful screening device for THM's. It is difficult to be specific on the number of samples that are required to properly define the range of THM's due to the variation of raw water quality and the types and reliability of treatment processes. A groundwater supply with little change in quality or treatment would have little variation in THM levels as compared to many surface water supplies. Relatively few samples are, therefore, needed. Surface water supplies are much more difficult to categorize and may require years of intensive (monthly) sampling to establish seasonal variations. Additional sampling may be required when unusual conditions occur in raw water quality (e.g. algae blooms, high turbidities, high or low water levels, increased temperatures, industrial spills or agricultural runoff) or when changes are made in the types and/or dosages of chemicals used in the treatment process.

A general outline of the procedures to follow for monitoring are presented in Figure 1. When the results (DAI method) of either the unquenched-treated (WTP) or distribution system samples are above a selected threshold value of 300 µg/L, resampling should occur with analysis by the purge and trap technique so that the result is comparable with the MAC. If the MAC is exceeded, the procedures in the Drinking Water Objectives should be followed, that is, three additional samples taken at the same location within a month. At this time, it would be advisable to collect, in addition, a raw-unquenched sample and more

FIGURE 1

SAMPLING REQUIRED AND ACTION NEEDED WHEN MONITORING THM's
(unquenched sample unless otherwise stated)


SAMPLES: - treated (WTP)
- distribution system (consumer's tap)
-at least yearly* preferably monthly to determine variability, after which less frequent sampling may be appropriate**
-analysis by DAI method
<300 µg/L
>300 µg/L (any one sample)
-continue sampling at least yearly until confident this level not exceeded
-resample and use purge and trap analysis
<MAC (350 µg/L by purge and trap)
>MAC
-monthly sampling***
-sampling may be reduced to the season when high levels expected when sufficient data collected
-follow Drinking Water Objectives format
-take 3 more samples at the same location within a month (Purge and trap analysis)
Avg. of 4 samples <MAC
Avg. of 4 samples >MAC
-monthly sampling (purge and trap analysis) until confident MAC not exceeded***
-sampling may be reduced to the season when high levels are expected after several years of data collection
-if more than one sample result from distribution system over MAC, treatment alternatives should be examined and if necessary implemented
-sampling, at least monthly, (purge and trap analysis) until confident MAC not exceeded***
-additional sampling from the raw water, the treated-quenched and the distribution system will determine the source of the THM's, where THM's are formed and verify the levels at the consumer's tap
-sampling may be reduced to the season when highest levels expected after several years of data collected

* yearly samples should always be taken when highest levels expected, based on previous data

** all changes in sampling and analysis protocol will be designated by MOE

*** sufficient samples should be analyzed by both the DAI and the purge and trap methods to establish a reliable relationship, and analysis can revert to just the DAI if results less than 300 µg/L (DAI)

distribution-unquenched samples to determine any potential source and the ultimate fate of the THM's leaving the water treatment plant. The treated-quenched sample should also be taken at this time since it would also help determine where the THM formation is occurring.

The literature of the past 10 years is replete with studies published by EPA and AWWA that deal with methods for the reduction of THM's. In 1982 AWWA republished the EPA manual "Treatment Techniques for Controlling Trihalomethanes in Drinking Water".[16] This publication lists over 250 references. For Ontario these are several published studies that deal with THM reduction.[11,12,13]

Roberts (1983) presented a lucid paper on the available technologies for the reduction of THM's.[14] These can be summarized into three categories: 1) removal of THM after chlorination (e.g. by aeration or activated carbon); 2) precursor removal before chlorination (e.g. by oxidation or changing the point of chlorination); and 3) alternative disinfection (e.g. chloramines or ozone). Each water supply and treatment process train is unique and treatment alterations for the reduction of THM's may require extensive pilot plant studies to determine their effectiveness and assess their ramifications.

With any proposed change in water treatment, especially if it concerns the disinfection process, it is very important that the safety of the drinking water not be jeopardized in terms of known risks from water-borne disease in order to control a possible risk from trace organic contaminants.[15] The Drinking Water Section, Water Resources Branch has been involved in many pilot and full scale studies to reduce THM's. It is recommended that regional and plant personnel contemplating such a change contact that MOE Section.

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# APPENDIX I

# DETAILED ANALYTICAL METHODS

DAI Method

This method of analysis was used on all samples. A Varian Gas Chromatograph Model 2440, equipped with a scandium tritide electron capture detector, a Varian Autosampler, Model 8000, and a recorder coupled to an Autolab, System IV, Electronic Integrator was used. The autosampler had a capacity for 60 sample vials of 2 mL each. The automatic injection device permitted adequate syringe flushing with the sample prior to the automatic sample injection. The injection volume was 9 µL and a 20-minute analysis time was used for each of the consecutive sample injections.

The GC column was a 9 ft (2.7 m) x ¼ inch (2 mm ID) glass column packed with Chromosorb 101 (60/80 mesh). The injector was operated at 230°C, the detector at 290°C and the column temperature was maintained isothermally at 158°C. The flow rate of the nitrogen was 30 mL/minute. Retention times and detection limits for the organohalides analyzed were as follows:

Retention Times and Detection Limits by the DAI Method

| Compound | Retention Time Minutes | Detection Limits* µg/L |
|---|---|---|
| Chloroform | 3.1 | 1 |
| Carbon Tetrachloride | 4.5 | 0.1 |
| Trichloroethylene | 5.1 | 2 |
| Bromodichloromethane | 6.5 | 0.5 |
| Chlorodibromomethane | 13.5 | 1 |

*Detection limit = 2 x noise level

The 2 mL glass vials were filled to just over 1 mL with the samples, or the standard solutions, by using disposable glass pipettes without suction. The glass vials, which had Teflon-lined septa inserted in the screwcaps were tightly closed and placed into the autosampler for injection into the GC. Vials of distilled "millipore" water were placed between sample vials to serve as controls. Each day, freshly prepared standard mixtures of the organohalides at concentrations of 10, 30, 50, 100, 150 and 200 µg/L were used to calibrate the GC. After eight samples were put through the GC, the 50 µg/L standard mixture was injected to ensure consistency of the GC performance throughout the day.

The types of organohalides produced were determined by the GC retention times while their levels were obtained by comparing their peak areas on the GC with the peak areas of the standard solutions. A Hewlett Packard Calculator-Plotter, Model 9830, was used to determine the organohalide concentrations in the sample by taking into account the slightly non-linear detector response obtained over the concentration range of the organohalide calibration standards. The slope of the calibration curves obtained from the organohalide standards served to indicate detector sensitivity within the concentration range tested. The sensitivity of the detector was checked each day when analyses were done and served at the same time to test for leaks in the GC system.

Sparging Method:

Volatile organohalides are sparged from the samples with an inert gas and then determined after GC separation as follows:

i) Gas Sparging: Into a 15 mL Pyrex glass vessel, a 5 mL sample was injected with a glass hypodermic syringe and sparged at room temperature, via a sintered glass inlet at the bottom, with helium gas onto a GC column. Care was taken to ensure that the volatiles were quantitatively removed from the sparging vessel by standardizing the sparging times. This was accomplished by subjecting standard solutions to a sparging time necessary for the removal of all "free" chloroform from the aqueous residues (as determined by the DAI method). The less volatile organohalides, however, are not completely removed during the sparging time, since water loss must be kept at a minimum when determining non-volatile chloroform in the sample residues.

ii) Gas Chromatographic Separation: A Varian 2100 GC containing a 6 ft (1.8 m) x ¼ inch glass column (2 mm ID), packed with Chromosorb 101 (60/80 mesh), was used for analysis. The organohalides, sparged from the aqueous samples with helium onto the head of the gas chromatographic column at room temperature, were chromatographically separated by raising the temperature of the column oven to 150°C at the rate of 20°C/minute followed by programming the temperature from 150°C to 200°C at 4°C/minute.

iii) Pyrolytic Hydrogenation: The effluent from the column was analyzed by a Hall electrolytic conductivity detector, operating in the chlorine mode. The furnace of the Hall detector was mounted directly over the detector base, and the quartz pyrolysis tube was attached to the base in place of the flame tip. Hydrogen was introduced at the detector base at a rate of 40 mL/minute. The pyrolysis oven was maintained at 800°C. The electrolyte solution used was a mixture of 10% isopropanol and 90% water, by volume.

iv) Determination: The responses of the Hall detector to the generated hydrogen chloride (which was dissolved in the isopropanol solution and passed through the detector) were plotted by a recorder to give a chromatogram. By measuring the peak heights obtained from a sample and correlating them with the peak heights from freshly prepared standards, quantification of the corresponding organohalides in the sample was accomplished. Under the sparging conditions used, only the "free" chloroform in the sample could be quantitatively determined while levels of the less volatile organohalides would depend on the extent of their volatilization during the specified sparging period. Longer sparging times were required to determine levels of the less volatile organohalides.

# APPENDIX II

## SURVEY SAMPLE RESULTS
## (DAI Analysis)

NOTE - concentration scale may change drastically between graphs even at the same location

Pages 36 - 257 are a series of coloured graphs that depict all the data from the 138 locations sampled. This information is available at MOE Regional Offices in Hamilton, Kingston, London, Sudbury, Thunder Bay and Toronto. In addition, copies of the report with all the raw data are in the Main and Laboratory libraries located in Toronto.

The shorter version of the report (without pages 36 - 257) has much of this information summarized in tables II and III in the Results and Discussion section. Any locations with levels warranting further discussion are dealt with in Appendix III.

## APPENDIX III

Assessment of locations where TTHM (DAI) results exceed 300 µg/L


| Location | Page No. |
|---|---|
| Atikokan | 259 |
| Bancroft | 260 |
| Bobcaygeon | 261 |
| Brantford | 262 |
| Cayuga | 264 |
| Casselman | 265 |
| Chapleau | 267 |
| Deseronto | 268 |
| Ear Falls | 269 |
| Emo | 271 |
| Fort Frances | 272 |
| Frankford-Well #1 | 273 |
| Hamilton | 275 |
| Hearst | 276 |
| Lindsay | 277 |
| Madsen | 279 |
| Napanee | 280 |
| Niagara-on-the-Lake | 281 |
| Odessa | 283 |
| Rainy River | 284 |
| Rockland | 286 |
| Smiths Falls | 287 |
| Thunder Bay -Loch Lomond | 289 |
| Verner | 290 |

LOCATION: Atikokan REGION: Northwestern

| SOURCE: Atikokan River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | 114 | NS | 248 | 282 | 302 |
| Highest TTHM (DAI) Levels | NS | 175 (June) | NS | 388 (Dec) | 443 (Oct) | 450 (June) |

TREATMENT PROCESS:

- Chlorination
- Fluoridation

DATA INTERPRETATION:

Sampling was sporadic except in the latter half of 1982 but for those analysed the threshold level of 300 µg/L was exceeded in the last three years of the survey. The sparged - DAI result on one sample revealed a dramatically lower level (90 µg/L) than the DAI method (349 µg/L). On the basis of this relationship, none of the sample results to date have exceeded the MAC. A possible cause of the high levels of TTHM (DAI) was the natural occurring colour in the raw water (30-40 Hazen Units) which is often associated with organic precursors.

PLAN OF ACTION:

1) Sampling should continue on a monthly basis using the purge and trap method of analysis to confirm that the THM levels do not exceed the MAC.
2) Once sufficient data has been collected and if a problem is apparent, an investigation into alternate treatment processes should be undertaken.

LOCATION: Bancroft REGION: Southeastern

| SOURCE: Clarke Lake | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 155 | 262 | 146 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 234 (Sept) | 716 (Sept) | 215 (July) |

TREATMENT PROCESS:

- Chlorination only

DATA INTERPRETATION:

Sampling was carried out for the last three years of the survey and it was sporadic in the final year. The only TTHM (DAI) level above the threshold concentration was 716 µg/L. The one sample that was analysed by the sparged - DAI technique produced a result of 100 µg/L compared to 147 µg/L for the DAI method. On the basis of this relationship, the one high sample result probably did exceed the MAC. There was sufficient data to indicate that the single high value was an anomally but more sampling is needed for confirmation.

PLAN OF ACTION:

Sampling should continue on a monthly basis, using the purge and trap technique, until sufficient data has been collected to determine if the peak levels are exceeding the MAC.

ADDITIONAL COMMENTS:

The present treatment process (chlorination only) does not allow for any feasible modifications that would reduce the THM levels. With the expected completion of a new conventional treatment plant (Nov., 1984) the THM levels should be considerably reduced.

LOCATION: Bobcaygeon REGION: Central

| SOURCE: Sturgeon Lake - Big Bob River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 231 | 190 | 275 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 334 (Sept) | 261 (June) | 275 (Jan.) |

TREATMENT PROCESS:

- Powdered activated carbon added for taste and odour control when needed
- Diatomaceous earth filters
- Chlorination

As of June, 1981, the following treatment process was adopted:

- Chlorination
- Conventional Treatment with alum coagulation
- Dual media (sand & anthracite) filtration

DATA INTERPRETATION:

Sampling was only conducted for the last three years of the survey. The only levels above the threshold of 300 µg/L occurred in 1980. A sample that was analysed by the sparged - DAI produced a result of 97 µg/L compared to 164 µg/L for the DAI method. On the basis of this relationship, the highest values did not exceed the MAC. Since the treatment processes were upgraded in June, 1981 much lower levels were recorded but unfortunately very few samples were taken.

PLAN OF ACTION:

Monthly sampling and analyses by the DAI method should be conducted to determine the TTHM variability with the new treatment process.

LOCATION: BRANTFORD REGION: West Central

| SOURCE: Grand River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 211 | 156 | 177 | 238 | 201 | NS |
| Highest TTHM (DAI) Levels | 285 (Nov) | 215 (June) | 315 (Aug) | 364 (Sept) | 274 (Feb) | NS |

TREATMENT PROCESS:

- Pre-chlorination (4.5 - 5.0 mg/L chlorine)
- Powdered activated carbon fed when needed for taste and odour control
- Conventional treatment with alum and activated silica coagulation
- Multi-media filtration
- Fluoridation using sodium silicofluoride
- Post chlorination with ammonia
- Post-pH correction using lime

DATA INTERPRETATION:

Samples were taken over a five year period and it was consistent for most of three years. During this period the threshold level was exceeded in the late summers of 1979 and 1980. Most results were below 250 µg/L. One sample was analysed by the sparged - DAI technique, and it produced a result of 161 µg/L which was considerably below the initial DAI value of 255 µg/L. Considering this information there does not appear to have been a noticeable problem to date (MAC not exceeded) but the raw water source may be subjected to intermittent high organic loading which could be the cause of high THM levels.

PLAN OF ACTION:

It is advisable to continue sampling with analysis by the purge and trap method, ensuring that samples are taken from June to September. On the basis of these results, it should be possible to determine if the MAC is exceeded.

LOCATION: Cayuga REGION: West Central

| SOURCE: Grand River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 141 | 213 | 165 | 156 | NS | 102 |
| Highest TTHM (DAI) Levels | 244 (June) | 259 (June) | 308 (Aug) | 258 (July) | NS | 196 (June) |

TREATMENT PROCESS:

- Pre-chlorination
- Alum and activated silica coagulation
- Conventional treatment - upflow solids contact clarifier
- Pressure filters

DATA INTERPRETATION:

The sampling was inconsistent during the survey period although the late summer months were sampled when higher levels would be expected. The threshold was exceeded once in regular sampling with a value of 308 µg/L. It was also exceeded in the special sample analysed by the DAI (331 µg/L) and subsequently analysed by the sparged - DAI (164 µg/L). On the basis of this data there appears to be no problem with THM levels at this location but the raw water source may be subjected to intermittent high organic loading which could cause higher THM levels.

PLAN OF ACTION:

1) Since the sampling thus far has been intermittent over five years, it should continue on a monthly basis (analysis by DAI) to determine the variability.
2) If the results still remain below the threshold level, sampling could then be reduced to the June to September period.

LOCATION: Casselman REGION: Southeastern

| SOURCE: South Nation River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 197 | 172 | 144 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 325 (Sept) | 374 (Sept) | 219 (July) |

TREATMENT PROCESS:

- Pre-chlorination
- Alum and polyelectrolyte coagulation
- Conventional treatment - upflow solids contact clarifier
- Dual media filtration
- Post chlorination
- Powedered activated carbon is fed whenever required for taste and odour control

DATA INTERPRETATION:

Monthly sampling was consistent in 1980 but more sporadic in 1981 and 1982. Peak levels were above the threshold level in two years (1980 and 1981) when the period June to September was sampled. Sparged - DAI analysis was performed on only one sample and it produced a result of 272 µg/L compared to 380 µg/L for the DAI method. The probable causes of organic precursors in the raw water were agricultural drainage and the byproducts of the decomposition of organic material. From all this data it appears that the threshold can be exceeded, possibly yearly, in late summer but the MAC probably has not been exceeded.

PLAN OF ACTION:

Sampling should continue on a monthly basis using the purge and trap

method of analysis especially in the June to September period when high levels are expected.

ADDITIONAL INFORMATION:

A pilot plant research study was conducted in 1982 to determine optional treatment for TTHM reduction. If future analysis shows that the MAC is exceeded, this information may be implemented.

LOCATION: Chapleau REGION: Northeastern

| SOURCE: Kebsquashing River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 198 | 219 | 114 | 102 | 135 | 126 |
| Highest TTHM (DAI) Levels | 280 (Oct) | 370 (July) | 197 (July) | 179 (Sept) | 182 (Sept) | 284 (Aug) |

TREATMENT PROCESS:

- Pre-chlorination (separate contact tank)
- Alum and polyelectrolyte coagulation
- Conventional treatment - upflow clarifier
- Dual media filtration
- Post pH correction using soda ash
- Post chlorination

DATA INTERPRETATION:

This location was consistently sampled for the six years of the survey. In 1978 four samples exceeded the threshold level of 300 µg/L. The one sample analysed by the sparged - DAI produced a result of 110 µg/L compared to 218 µg/L for the regular DAI analysis. The yearly peak levels always occurred during the period from June to October. These higher TTHM (DAI) levels might be due to the natural organics which were responsible for the colour of 70 to 80 Hazen units in the raw water. It was concluded that the threshold level could be exceeded but usually was not and the MAC probably was not exceeded during the survey.

PLAN OF ACTION:

Since the results from the past four years of intensive sampling did not exceed the threshold level, the sampling may be reduced to yearly, between June and October, with analysis by the DAI method.

LOCATION: Deseronto REGION: Southeastern

| SOURCE: Bay of Quinte (L. Ontario) | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 85 | 135 | 155 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 105 (Sept) | 227 (Jan) | 337 (June) |

TREATMENT PROCESS:

- Pre-chlorination
- Conventional treatment process with alum and polyelectrolyte addition (upflow clarifier)
- Dual media filtration
- Granular activated carbon contact for taste and odour control
- Post chlorination
- Post pH correction

DATA INTERPRETATION:

This location was sampled consistently for two years of the program and only one result exceeded the threshold; most of the results were below 200 µg/L. Analysis was not performed by the sparged - DAI method but at all other locations the results were always considerably below those by the DAI method. It is therefore very unlikely that the MAC was exceeded.

PLAN OF ACTION:

1) Analysis by the purge and trap method is needed to confirm that the MAC is not exceeded. The samples should be taken monthly.
2) If the levels by the DAI analysis remain below the threshold, at least yearly samples should be taken, preferably in June or July.

LOCATION: Ear Falls REGION: Northwestern

| SOURCE: English River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 249 | 235 | 227 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 377 (Aug.) | 347 (Aug.) | 517 (July) |

TREATMENT PROCESS:

- Prechlorination
- Alum coagulation in an upflow clarifier
- Dual media gravity filtration
- Post pH correction (soda ash)
- Post chlorination
- Fluoridation (sodium fluoride)

DATA INTERPRETATION:

Sporadic sampling was conducted from 1980-1982. The threshold level was exceeded yearly on the samples submitted during the survey program. The sparged-DAI result (133 µg/L on one sample) revealed a lower level than the DAI method (172 µg/L). On the basis of this relationship, the peak levels in 1980 and 1981 were below the MAC but the MAC was probably exceeded in 1982.

PLAN OF ACTION:

1. Sampling should continue on a monthly basis, using the purge and trap method of analysis to ensure the THM levels do not exceed the MAC.

2. Once sufficient data has been collected a re-evaluation of sampling frequency and method of analysis will be necessary.
3. An investigation into alternate treatment methods for THM reduction should be conducted.

LOCATION: Emo REGION: Northwestern

| SOURCE: Rainy River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 239 | 140 | 166 | 201 | 190 | 165 |
| Highest TTHM (DAI) Levels | 394 (Sept.) | 197 (May) | 263 (Nov.) | 333 (Aug.) | 309 (Sept.) | 242 (Oct.) |

TREATMENT PROCESS:

- Prechlorination (terminated in 1979)
- Alum coagulation with polyelectrolyte addition (conventional treatment)
- Post pH correction (soda ash)
- Post chlorination, prior to filtration (after 1979)

DATA INTERPRETATION:

This location was sampled consistently in all six years of the survey and the threshold was exceeded once per year in 1977, 1980 and 1981. On the single sample analyzed by the sparged-DAI method the result was 214 µg/L compared to 345 µg/L by the DAI method. In 1979 an attempt was made to reduce THM levels by changing from just prechlorination to chlorination prior to filtration. The levels were not lowered, possibly due to the inability of the treatment process to remove the THM precursors.

On the basis of available information for the survey period, the MAC was not exceeded.

PLAN OF ACTION:

Sample collection should be concentrated from July until November, which historically has produced the higher levels of TTHM (DAI). The analysis should be by the sparged-DAI technique to confirm that the MAC is not exceeded.

LOCATION: Fort Frances REGION: Northwestern

| SOURCE: Rainy Lake | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 75 | 117 | 126 | 170 | 150 | NS |
| Highest TTHM (DAI) Levels | 105 (Nov.) | 203 (Aug.) | 140 (Sept.) | 335 (Aug.) | 241 (March) | NS |

TREATMENT PROCESS:

- Chlorination (gaseous)
- Fluoridation

DATA INTERPRETATION:

Sampling was conducted for five years of the survey. The treated-unquenched sample results only exceeded the threshold of 300 µg/L once, but the distribution system samples exceeded this value four times. Possibly this was due to a free chlorine residual leaving the WTP (a short contact time) and reacting with organic material in the mains. All of the results by the DAI method were below 350 µg/L. The single sample analyzed by the sparged-DAI produced a result of 78 µg/L compared with 127 µg/L for the DAI method. From the data collected to date, the MAC has not been exceeded.

The water treatment as it exists does not allow for modifications that would reduce the THM levels. Any future plant expansion that would remove the organic precursors should lower the THM levels.

PLAN OF ACTION:

Sampling should continue during the summer and fall months and the analysis should be by the purge and trap technique to confirm the relationship between the two methods of analysis.

LOCATION: Frankford-Well #1 REGION: Southwestern

| SOURCE: Well #1 | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 358 | 909 | 397 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 1082 (June) | 2367 (Apr.) | 1534 (Feb.) |
| Highest TTHM (DAI) Level in the Distribution System | NS | NS | NS | 34 (June) | 27 (Aug.) | 13 (May) |

TREATMENT PROCESS:

-Chlorination (sodium hypochlorite)

DATA INTERPRETATION:

This location was sampled monthly for three years of the survey but only one of those years (1981) was complete. Extremely high TTHM (DAI) values were found in the treated water at the plant, especially in 1981 but very low values were found in the distribution system samples even at the first house (max. level 34 µg/L). The high values were confined to the treated water samples and were not detected in the water the consumers were drinking.

The raw water is drawn from a 40 ft well and chlorinated with hypochlorite. The sample for treated water was taken just a short distance from the point of chlorination, allowing minimal contact time. An inspection was made of the water works to try and determine the source of the contamination and at the same time verify these high levels of THM's. There did not appear to be any abnormalities in the treatment methods nor in the sampling procedures. Chemical analysis for samples taken in September, 1981 of the raw and treated water showed that the chlorinated water at the water plant had a drastic increase in sodium and chloride levels, not evident in the distribution system. These high levels were caused by the sodium hypochlorite solution and were

equivalent to a chlorine dosage of almost 200 mg/L. Since the actual chlorine dosage was only 1.5 mg/L, these high levels of Na and Cl prove there was insufficient mixing before the sample was taken. The very high TTHM (DAI) levels frequently found in this sample (in excess of 2000 µg/L) could have been caused in part by the very high chlorine dosage but may have also been caused by other factors.

In October, 1981 modifications were made to the works to replace the valve used for sampling as well as replace the tubing used to feed the hypochlorite solution. In April, 1982 the operational staff discovered and removed a weight which had been used for the hypochlorite feed line. It had dropped off and was at the bottom of the tank. Since the removal of this weight, levels of TTHM (DAI) have dropped sharply for those samples collected after chlorination. The high values were obviously anomalous. An on-going monitoring program of the system is being done and to date, continued low levels (<30 µg/L) have been detected in the samples collected throughout the distribution system.

PLAN OF ACTION:

Since there were always low levels of TTHM (DAI) in the distribution system, only yearly samples are now required with analysis by the DAI method. Little variation is expected in the ground water source so samples may be collected at any time.

LOCATION: Hamilton REGION: West Central

| SOURCE: Lake Ontario | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 30 | 26 | 57 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 36 (Aug. & Dec.) | 38 (Oct.) | 384 (June) |

TREATMENT PROCESS:

- Prechlorination
- Conventional treatment process with alum coagulation
- Dual media filtration
- Ammonia - chlorine treatment whereby ammonia is added to form a combined chlorine residual
- Fluoridation
- Sulfur dioxide used for dechlorination

DATA INTERPRETATION:

Sampling has been reasonably consistent for two and a half years and the threshold was exceeded once in June of 1982. All 23 other samples analyzed were below 50 µg/L (DAI analysis). The one high level must be considered an anomaly and no apparent problem exists.

PLAN OF ACTION:

Sampling should continue on a yearly basis, with analysis by the DAI method.

LOCATION: Hearst

REGION: Northeastern

| SOURCE: Matawishkwia River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | 447 | 183 | 161 | 133 |
| Highest TTHM (DAI) Levels | NS | NS | 616 (May) | 334 (May) | 233 (July) | 209 (Aug.) |

TREATMENT PROCESS: - only chlorination

In Nov./79, the operation of the new treatment plant began as follows:

- Prechlorination
- Pre pH and alkalinity correction with soda ash
- Conventional treatment - coagulation with alum and a polyelectrolyte

In Aug./81, soda ash was replaced by sodium hydroxide for pH and alkalinity adjustment. Lime was also used for post pH correction.

DATA INTERPRETATION:

Sampling was conducted for four years of the survey and the threshold level of 300 µg/L was exceeded in three samples collected in 1979 when the treatment consisted of only chlorination. Since the new WTP became operational the threshold was exceeded once, in 1980, when the WTP was not functioning properly. Following that upset, the levels were consistently below 250 µg/L. On the single sample analyzed by the sparged-DAI method, the result was 50 µg/L compared to 74 µg/L for the DAI method. On the basis of this relationship, no results exceeded the MAC with the new WTP in operation. No apparent problem now exists with THM levels.

PLAN OF ACTION:

Sampling can be reduced to yearly with analysis by the DAI method.

LOCATION: Lindsay REGION: Central

| SOURCE: Scugog River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | 317 | 346 | 500 | 469 | 236 |
| Highest TTHM (DAI) Levels | NS | 473 (Sept.) | 691 (June) | 855 (Aug.) | 619 (July) | 323 (Aug.) |

TREATMENT PROCESS:

- Prechlorination
- Conventional alum coagulation with activated silica in a solids contact clarifier
- Chlorine dioxide (spring and summer) addition for taste and odour control
- Gravity filtration
- Post chlorination in the clear well

April, 1982 - Prechlorination discontinued

DATA INTERPRETATION:

Sampling has been consistent since 1978 and until the end of 1981 the TTHM (DAI) levels had exceeded the threshold of 300 µg/L regularly in all but the winter months. Levels over 500 µg/L usually occurred several times per year. One sample that was analyzed by the sparged-DAI produced a result of 183 µg/L compared to 270 µg/L for the DAI method. On the basis of this relationship, the MAC was exceeded for at least a small portion of each year sampled until 1982. In April of that year the prechlorination was discontinued in an attempt to reduce these high levels. Following this change all the sample results remained below 350 µg/L by the DAI analysis method, well below the MAC. Some of the results have continued to exceed the threshold level but the situation appears to be under control.

PLAN OF ACTION:

It is important to continue monthly sampling, using the purge and trap analysis, to confirm that the MAC is not exceeded.

LOCATION: Madsen REGION: Northwestern

| SOURCE: Russett Lake | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 219 | 393 | 341 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 406 (Dec.) | 731 (Nov.) | 543 (July) |
| Highest TTHM (DAI) Level in the Distribution System | NS | NS | NS | 343 (Dec.) | 332 (Mar.) | 332 (May) |

TREATMENT PROCESS: - Chlorination only

In 1984 - new intake, low lift pumps, ground level storage and chlorination facilities brought on stream.

DATA INTERPRETATION:

Sampling was conducted for three years of the survey. The treated-unquenched sample results were frequently above the threshold of 300 µg/L by DAI analysis but rarely over 500 µg/L. One sample analyzed by the sparged-DAI produced a result of 92 µg/L compared to 116 µg/L for the DAI method. On the basis of this relationship, the MAC was exceeded at least once per year in these samples. However, the distribution system sample results were all below 350 µg/L by the DAI method, which means they were well below the MAC.

The water treatment as it exists does not allow for modification that would reduce the THM levels. Any future treatment processes that would remove the organic precursors should lower the THM levels.

PLAN OF ACTION:

Monthly sampling should continue and the analysis should be by the purge and trap method. More samples from the distribution system are needed to confirm that the MAC is not exceeded. Considering the yearly high levels that have occurred, it may be advisable to examine alternative method of disinfection or the installation of a conventional treatment plant. The changes to the water system in 1984 will probably have a limited effect in reducing THM's.

LOCATION: Napanee REGION: Southeastern

| SOURCE: Napanee River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 54 | 55 | 74 | 71 | 150 | 120 |
| Highest TTHM (DAI) Levels | 117 (May) | 102 (July) | 115 (Sept.) | 98 (Aug. & Sept.) | 245 (July) | 332 (May) |

TREATMENT PROCESS:

- Prechlorination
- Conventional treatment process with alum coagulation
- Dual media filtration
- Powdered activated carbon used when needed (for taste and odour control)
- Post pH correction with lime

In April/84 - raw water source changed to Lake Ontario

DATA INTERPRETATION:

Monthly samples have been taken consistently for the whole survey period of six years. The analysis results were usually below 150 µg/L and only one set of monthly samples (May, 1982) exceeded the threshold level of 300 µg/L. The highest result from this set was from the distribution system with a value of 365 µg/L. Although no sparged-DAI analysis were done on samples from this location, the results of this method always have been considerably lower than the DAI results. It is, therefore, reasonable to say that the MAC was not exceeded in these abnormally high sample results.

PLAN OF ACTION:

Monthly sampling should continue with analysis by the purge and trap technique to determine the relationship between the results of this method with the DAI method. If the levels remain low, it would be possible to reduce the sampling to yearly and analyze by the DAI technique.

LOCATION: Niagara-on-the-Lake REGION: West Central

| SOURCE: Niagara River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 36 | 27 | 36 | 29 | 41 | 69 |
| Highest TTHM (DAI) Levels | 46 (Oct) | 39 (Sept) | 44 (Aug) | 47 (Aug) | 61 (Mar) | 297 (June) |
| Highest TTHM (DAI) Levels in Distribution System | NS | NS | NS | 49 (Aug) | 122 (June) | 397 (June) |

TREATMENT PROCESS:

- Pre-chlorination
- Alum Coagulation
- Filtration
- Powdered Activated Carbon used periodically in the summer months for taste and odour control.

August 1982 - potable water supplied by St. Catherines W.T.P. (Niagara-on-the-Lake water works closed).

DATA INTERPRETATION:

Monthly samples were taken consistently for all six years of the survey. The TTHM (DAI) results were usually less than 60 µg/L except for the June samples in 1982 when the result from the distribution system almost reached 400 µg/L. These sample results appear anomalous, however, on the basis of analysis by the sparged-DAI method at other locations the MAC was not exceeded.

In August 1982 the potable water was supplied by the St. Catherines water treatment plant, and the sampling for this survey ceased at the same time. Results from the St. Catherines water supply indicate levels of TTHM (DAI) in the <40 µg/L range.

PLAN OF ACTION:

Enough sampling should be done to confirm the expected low levels of TTHM (DAI). Samples should be collected from various locations in the distribution system.

LOCATION: Odessa REGION: Southeastern

| SOURCE: Millhaven Creek | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 165 | 194 | 212 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 270 (Aug.) | 331 (Oct.) | 410 (June) |

TREATMENT PROCESS:

- Prechlorination
- Alum coagulation (solids contact clarifier)
- Dual media filtration
- Granular Activated Carbon contact chamber (taste and odour control)
- Post pH correction
- Post chlorination

DATA INTERPRETATION:

Monthly samples have been taken consistently for the last three years of the survey period. The peak levels of TTHM (DAI) occurred in the months from July to October. For two years the peak values were over the threshold of 300 µg/L. The one sample analyzed by the sparged-DAI produced a result of 93 µg/L compared to 159 µg/L for the DAI method. On the basis of this relationship no sample results have exceeded the MAC.

PLAN OF ACTION:

Monthly sampling from July to October should continue and the analysis should be performed by the purge and trap technique to establish the levels in relation to the MAC.

LOCATION: Rainy River

REGION: Northwestern

SOURCE: Rainy River

TREATED - UNQUENCHED WTP SAMPLES

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|
| TTHM (DAI) Average Annual Levels | NS | NS | 208 | 184 | 163 | 152 |
| Highest TTHM (DAI) Levels | NS | NS | 260 (May) | 273 (Oct.) | 273 (Aug.) | 264 (Nov.) |
| Highest TTHM (DAI) Levels in Distribution System | NS | NS | 606 (July) | 260 (Oct.) | 236 (Aug.) | 246 (Nov.) |

TREATMENT PROCESS:

- Before 1979 treatment consisted of chlorination only
- Conventional treatment began in April 1980 (alum and polyelectrolyte)
- Prechlorination (April-Dec., 1980)
- Post chlorination began in January 1981 to present
- Soda ash for post pH correction

DATA INTERPRETATION:

This location was sampled for four years (1979-1982) and the last two years were sampled most months. The two sample results that exceeded the threshold level of 300 µg/L (by the DAI method) were from the distribution system in the first year of sampling. The highest value of 606 µg/L may have exceeded the MAC. At this time, the treatment process was just chlorination. In April 1980, conventional treatment with only prechlorination was initiated and in January 1981 the point of chlorination was changed to the end of the treatment process. Subsequently, no sample results have exceeded 300 µg/L TTHM (DAI).

PLAN OF ACTION:

Since there have been acceptable THM levels with the improved water quality from the new WTP and there are two years of good data, the sampling can be reduced to yearly (between July and November) with analysis by the DAI method.

LOCATION: Rockland REGION: Southeastern

| SOURCE: Ottawa River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 70 | 31 | 19 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 314 (Aug.) | 65 (June) | 59 (Oct.) |

TREATMENT PROCESS:

- Prechlorination
- Alum and polyelectrolyte addition
- Conventional treatment - clarifier
- Filtration
- Post pH correction with lime

DATA INTERPRETATION:

Sampling has been conducted for THM's in the last three years of the survey (1980-1982). The TTHM (DAI) results were always below 75 µg/L except for one sample in August, 1980 that peaked just over the threshold of 300 µg/L. One sample that was analyzed by the sparged-DAI technique produced a result of 26 µg/L compared to 38 µg/L for the DAI method. On the basis of this relationship, the MAC was not exceeded. The considerable amount of data following the one high value indicates that it was an anomaly.

PLAN OF ACTION:

Sampling should continue on a yearly basis with analysis by the DAI technique.

LOCATION: Smiths Falls REGION: Southeastern

| SOURCE: Rideau River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 78 | 75 | 65 | 81 | 175 | 210 |
| Highest TTHM (DAI) Levels | 133 (April) | 125 (June) | 158 (June) | 189 (Aug.) | 466 (Aug.) | 451 (June) |

TREATMENT PROCESS:

- Prechlorination
- Alum coagulation - conventional treatment
- Filtration
- Post chlorination
- Powdered Activated Carbon (for taste and odour control)
- Fluoridation - sodium silicofluoride

DATA INTERPRETATION:

This location has been sampled for all six years of the survey and the levels were all below 200 µg/L from 1977 to 1980. In 1981 the levels were considerably higher probably due to higher chlorine dosages and several TTHM (DAI) results were above the threshold of 300 µg/L. Sample results from one month in 1982 also exceeded this level. A single sample that was analyzed by the sparged-DAI produced a result of 248 µg/L compared to 355 µg/L for the DAI method. On the basis of this relationship, the MAC was not exceeded by any analysis in the survey.

PLAN OF ACTION

Monthly samples should be taken from June until September and analyzed by the purge and trap technique. If the levels return to the previously low values, sampling could be reduced to yearly with analysis by the DAI method.

## ADDITIONAL INFORMATION

Pilot plant tests conducted by MOE (1975-77) showed that ozone treatment improved the finished water quality by reducing the colour, which could reduce the required dosage of chlorine and probably reduce the THM levels.

LOCATION: Thunder Bay - Loch Lomond REGION: Northwestern

| SOURCE: Loch Lomond | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | 106 | 110 | 110 | 116 | 188 | 168 |
| Highest TTHM (DAI) Levels | 183 (Sept.) | 143 (Oct.) | 130 (Nov.) | 189 (Sept.) | 219 (July) | 242 (Dec.) |
| Highest TTHM (DAI) Levels in Distribution System | NS | NS | 123 (Dec.) | 181 (Sept.) | 312 (July) | 214 (Mar.) |

TREATMENT PROCESS:

- Chlorination

June, 1981 - Stabilization using lime and carbon dioxide

DATA INTERPRETATION:

Monthly sampling was consistent for all six years of the survey. TTHM (DAI) levels were always below 250 µg/L, except for one result in the summer of 1981 that just exceeded the threshold with a value of 312 µg/L. Based on special analyses performed by the sparged-DAI method at other locations, this result was obviously far below the MAC and appears to be anomalous.

PLAN OF ACTION:

The sampling can be reduced to yearly with analysis by the DAI method.

LOCATION: Verner REGION: Northeastern

| SOURCE: Veuve River | | | | | | |
|---|---|---|---|---|---|---|
| TREATED - UNQUENCHED WTP SAMPLES | | | | | | |
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| TTHM (DAI) Average Annual Levels | NS | NS | NS | 110 | 97 | 128 |
| Highest TTHM (DAI) Levels | NS | NS | NS | 176 (Aug.) | 200 (Aug.) | 304 (Aug.) |

TREATMENT PROCESS:

- Prechlorination (summer months chlorine dioxide used)
- Conventional treatment process with alum and polyelectrolyte coagulation
- Dual media filtration
- Post pH correction with soda ash
- Post chlorination

DATA INTERPRETATION:

Sampling for THM's was done during the last three years of the survey. All of the results (DAI analysis) were below 225 µg/L except for one month in 1982 when the treated-unquenched sample result (304 µg/L) just exceeded the threshold and the distribution system sample result was 353 µg/L. There have not been any special analysis performed by the sparged-DAI method, to date, however, at all other locations tested the results were considerably lower than those by the DAI method. On the basis of this information, it is very unlikely that the MAC was exceeded.

PLAN OF ACTION:

Monthly sampling should continue from June to September, when peak levels are expected, with analysis by the purge and trap method to confirm the relationship with the DAI technique and to ensure that the MAC is not exceeded. If the results remain low, the sampling can be reduced to yearly with analysis by the DAI method.